Space Exploration Enabled by Telepresence: Combining Science and Human Exploration

Based on Findings from:

"Exploration Telerobotics Symposium"

May 2-3, 2012

NASA Goddard Space Flight Center

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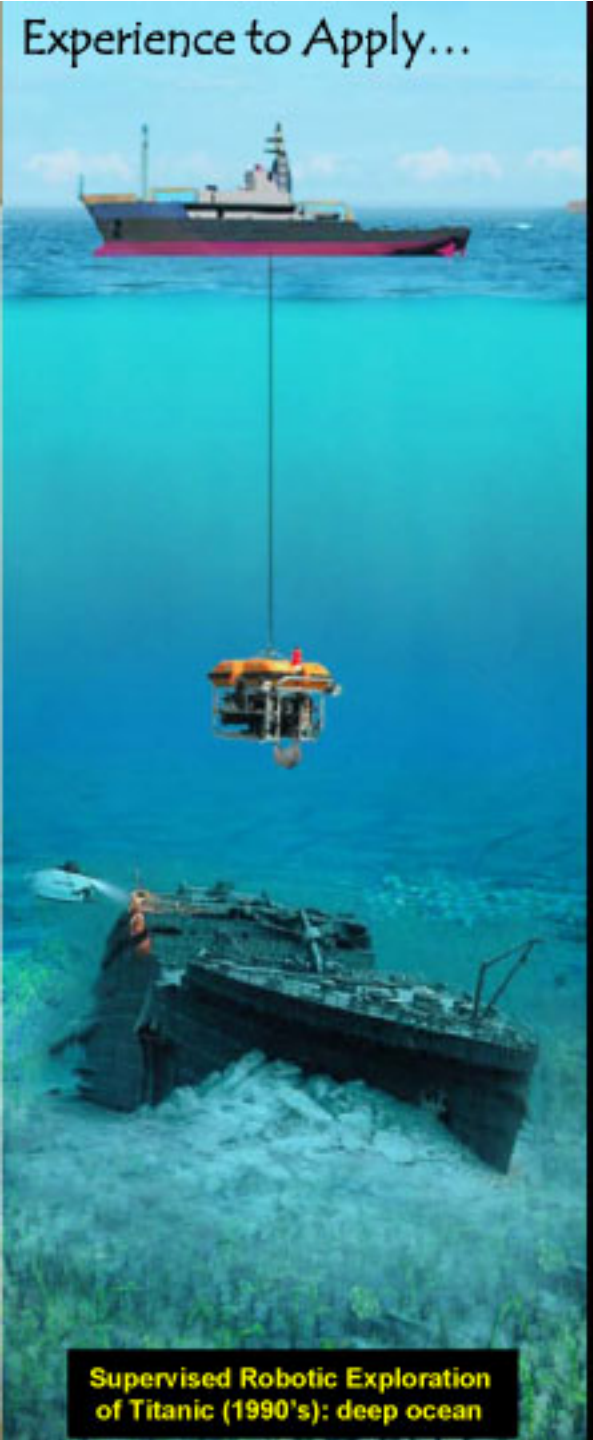
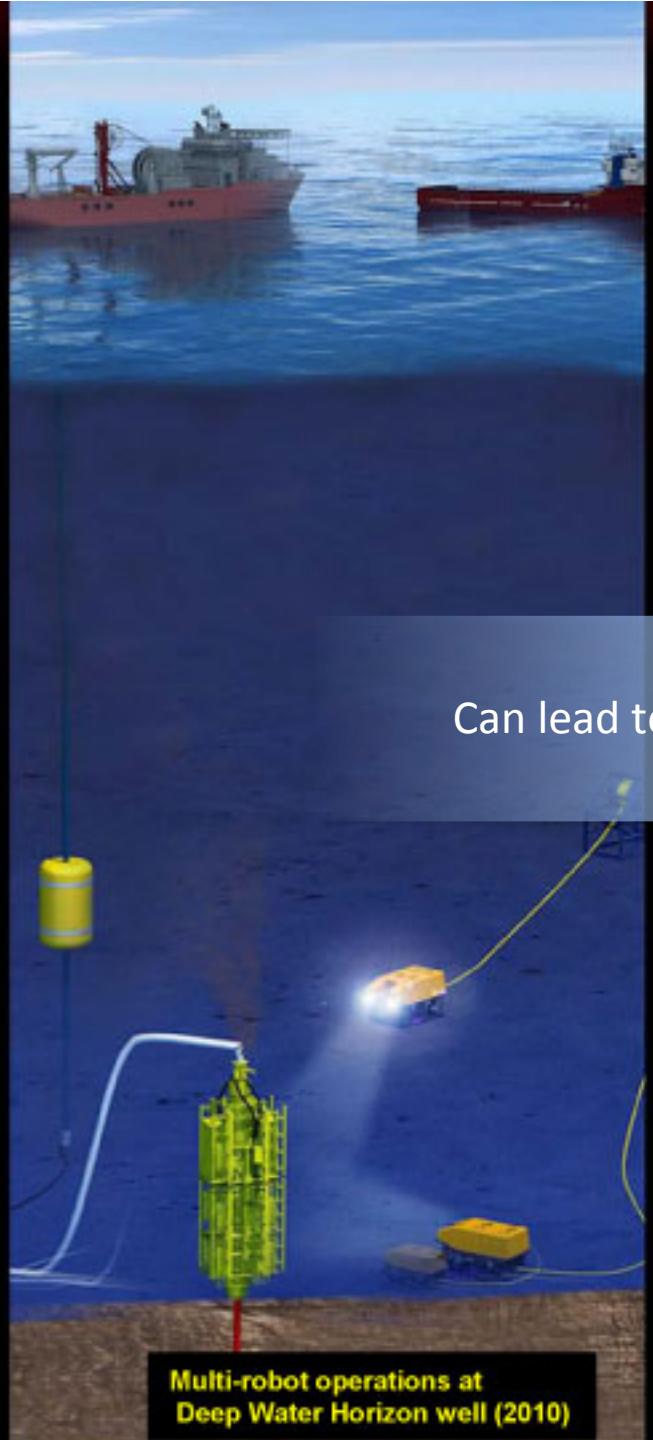
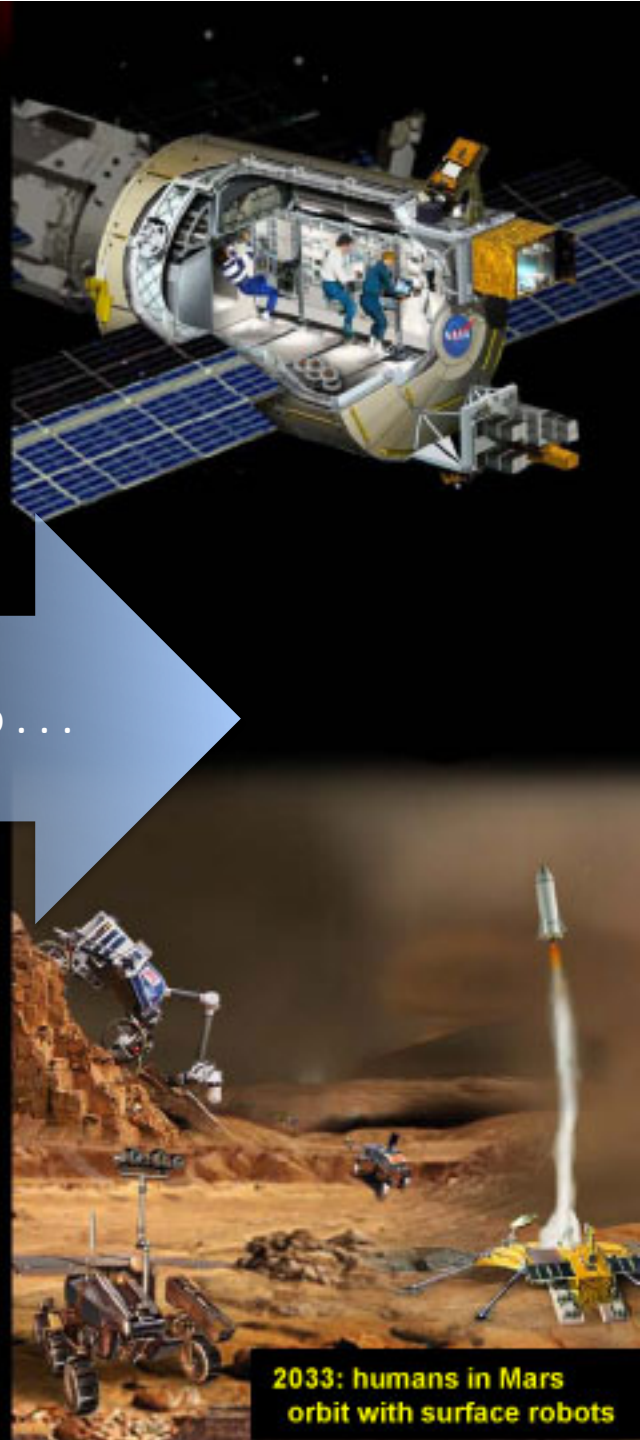
http://telerobotics.gsfc.nasa.gov/

October 4, 2012


Experience to Apply…
Supervised Robotic Exploration of Titanic (1990's): deep ocean


Multi-robot operations at Deep Water Horizon well (2010)


2033: humans in Mars orbit with surface robots

Can lead to . . .

The GSFC Exploration Telerobotics Symposium

- Goal: Assessment of **opportunities** & **challenges** of **telepresence for space exploration**
  - Science, Human Space Flight, Technology
- Attendence: Approximately 100 professionals
  - "**NASA not just talking to NASA"** - NASA discussing with the community – science & technology experts ; small/large industry, academia, international space agencies
- Output: Report to NASA and outreach to greater community
  - Findings and observations delivered to HQ (in progress)
  - Additional presentations to professional conferences, engagement with media

Photo: Dr. Ruthan Lewis

Symposium Outreach

Global Space Exploration Conference

22-24 May 2012
L'Enfant Plaza Hotel, Washington, DC, USA

SPACE.COM

How Telerobotics Could Help Humanity Explore Space

by Leonard David, SPACE.com's Space Insider Columnist
Date: 08 May 2012 Time: 10:44 AM ET

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SPACE INSIDER — Leonard David Columnist

Safely tucked inside orbiting habitat, space explorers use

GREENBELT, Md. — Advances in telerobotics are in high gear here on Earth, enabling scientists to plumb the deepest oceans, extract resources from dangerous mines and even carry out high-precision surgery from thousands of miles away.

Now researchers are considering ways to adopt and adapt telerobotics for more far-reaching duties — in outer space. The ability

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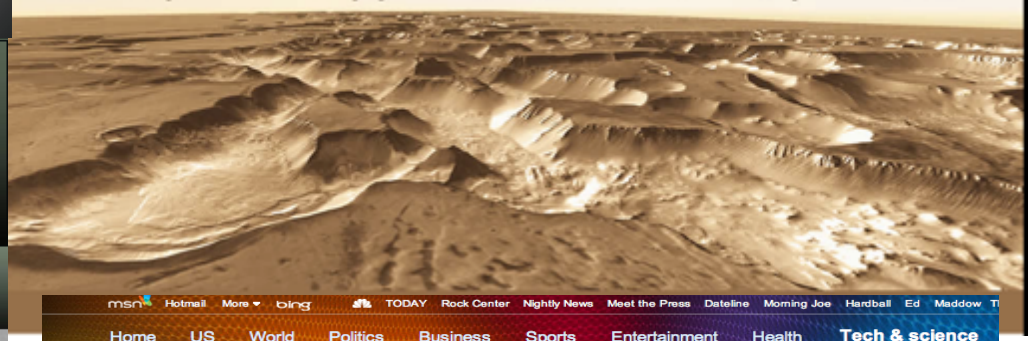
Concepts and Approaches for Mars Exploration



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How Telerobotics Could Help Humanity Explore Space

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By Leonard David
SPACE.com
updated 5/9/2012 6:19:39 AM ET

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GREENBELT, Md. — Advances in telerobotics are in high gear here on Earth, enabling scientists to p
the deepest oceans, extract resources from dangerous mines and even carry out high-precision surge

Human Exploration Spectrum: *Presence* to *Telepresence*

Mission Cost and Risk

Human Awareness on Site LOW

Telepresence from Orbit

Boots on the Ground

Curiosity on Mars

Human Dexterity on Site HIGH

High Latency

Telepresence

Low Latency

On-Site Presence

Three Essential Capabilities Enable Effective Telepresence

- *Low communication latency,*

  comparable to human response time

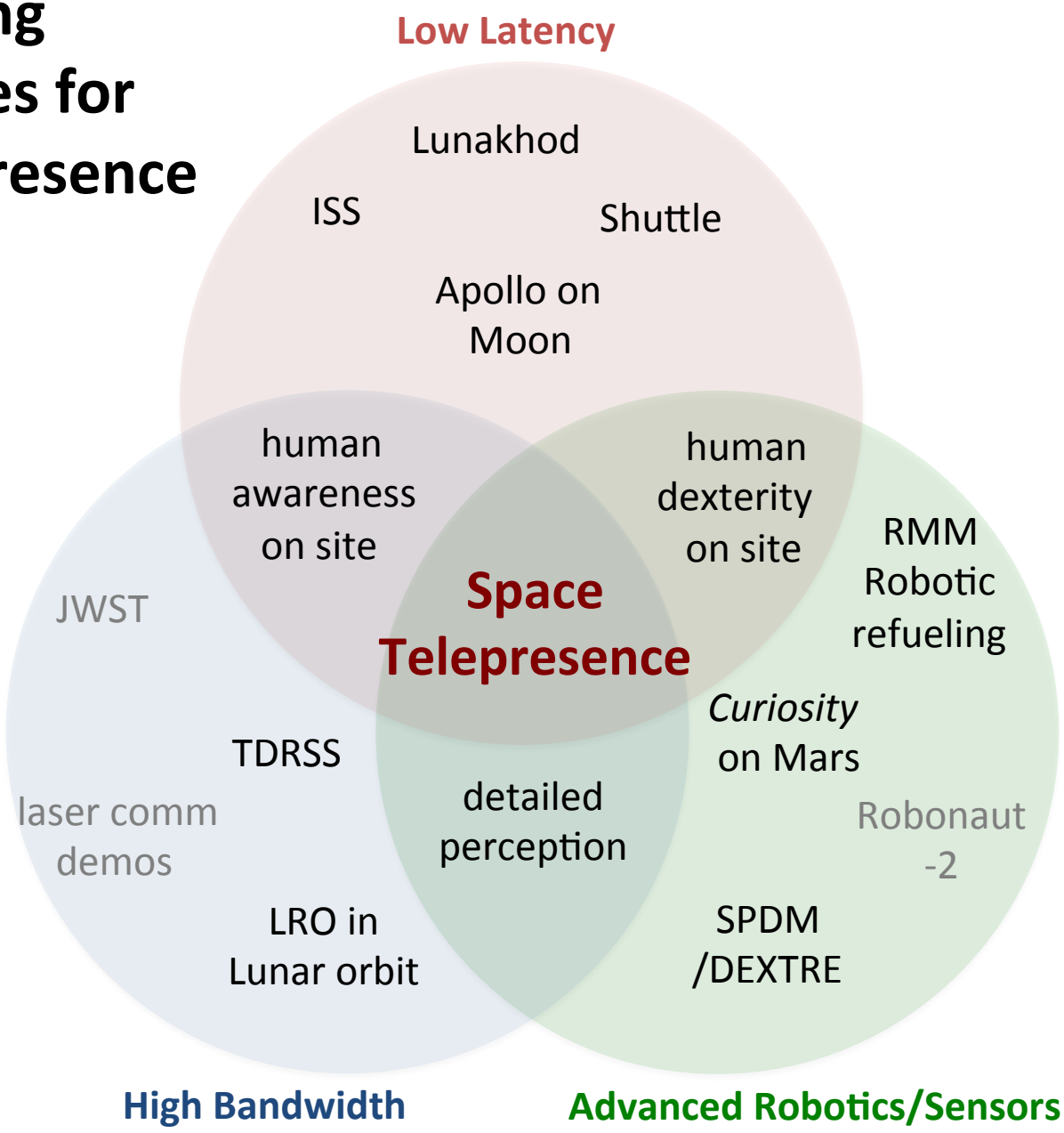
- *High bandwidth*

  comparable to human eye-brain *(~10 Mb/s)*

- *High capability action surrogates (advanced robotics)*

  mobility and sensing comparable to human

Enabling Capabilities for Space Telepresence



Why Explore via Telepresence?

- Entry, Descent, and Landing (EDL) and ascent are **risky and expensive**.
- Low latency, advanced robotics, and high bandwidth are **independently enabling**. Applied together, a powerful new capability for human exploration.
- Humans may be **severely constrained** in current EVA suits.
- Key technologies for are **at hand or in the near future**.
- Human surface exploration requires **special ECLSS systems**.
- Surfaces of other worlds - **contamination issues** complicate human operations.
- A human can be only in **one place at a time** at an exploration site.
- **Planetary protection issues** make humans potentially harmful or harmed.
- Opens up destinations humans **may never directly visit** (e.g. Venus, Titan)
- **Build upon terrestrial experience**, make field science "as if we were there".

Exploration telepresence can lower cost and risk to humans, increase capabilities, amplify science return and even create new science.

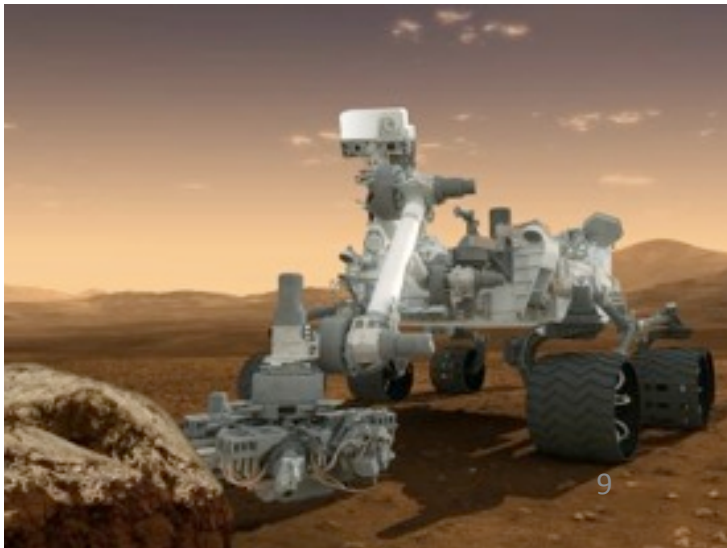
Selected Breakout Session Findings: Science

- **Examples of scientific explorations where telepresence *may* be enabling:**
  - *Volatiles on the Moon particularly within permanently shadowed regions*
  - *Lunar farside astrophysical observatory and surface geophysical/interior network*
  - *Mars surface biogeochemical sampling as part of search for signs of ancient life*
  - *Mars sample return*

- **New science can be enabled via telepresence at places that are**
  - *Distant (e.g., Mars, Titan)*
  - *Hostile to humans (e.g., cold lunar polar regions , surface of Venus, Titan, etc.)*

- **Contemporary commercial/defense telepresence** instructive with regard to space science exploration

- **As latency reduced, natural breakpoint for science?**
  - *For Moon: if seconds, do from Earth;*
    if fractional seconds, do from orbit nearby



Selected Breakout Session Findings: Human Space Flight

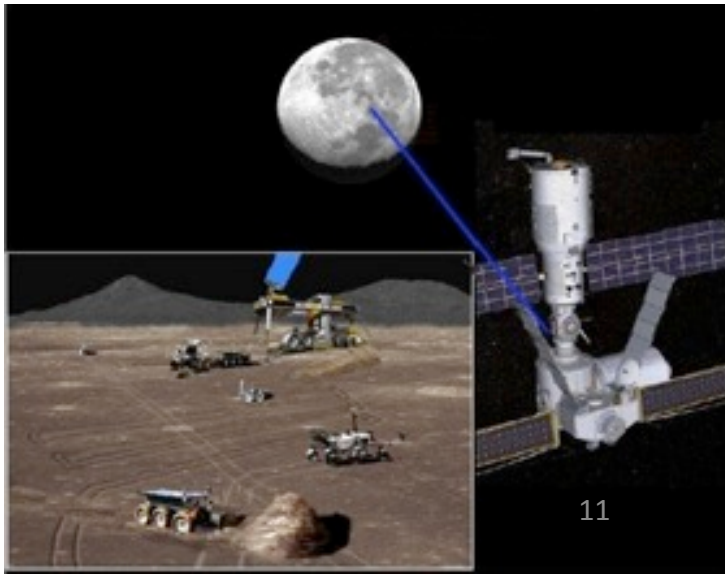
- **Human space flight capabilities enabled by telepresence**
  - *Enables operations in hostile, inaccessible, or limited-access environments.*
  - *Expands the range of environments in which human activity can be undertaken.*
  - *Enables improvisation in response to changing conditions, unexpected, unplanned*
  - *Reduces mission risk via improved situational awareness*
  - *Offers opportunities for public involvement in participatory exploration*

- **Human space flight scenarios that will be enhanced by telepresence:**
  - *Operations from orbit or on the surface remotely from the local exploration site*
  - *Assembly operations of large space structures*
  - *Safe NEO proxops with stand-off human crew*
  - *Service operations by spacecraft crew*
  - *Robot assistants controlled from Earth*

Source: Boeing

Selected Breakout Session Findings: Technology

- **Manipulation capabilities to advance telepresence**
  - *Bilateral force-reflection to feel/sense objects in remote environment*
  - *Grasp planning in unstructured environments benefits from direct teleoperation*
- **Mobility capabilities to advance telepresence**
  - *Move "like a field scientist" and adapt optimally questions and discoveries*
  - *Super-human mobility (e.g., flying) provides different perspectives, scales, venues*
- **Sensing and perception capabilities to enhance telepresence**
  - *High-data volumes provide situation awareness for real-time decision making*
  - *Haptics do not need low latency or high bandwidth*
- **Human-systems integration for telepresence**
  - *Multiple control modes - humans in proximity and on Earth (e.g. MSL) after humans depart*
- **High-bandwidth and telepresence**
  - *An enabling capability independent of latency*
  - *May multiply value of low of latency*



Suggested Next Steps

- Identify analogs for telepresence exploration on Earth as guided by NASA HQ and consistent with community priorities,
  - *Determine value and decision matrix of cost/benefit for science, exploration*
- Organize workshops and other similar organized interactions with the community
  - *Topic- and scenario-specific*
  - *Continue assessment of telepresence: low/high-latency, low/high-bandwidth*
- Organize field-based multi-scale human-robotic interactions with multiple latencies at analogue sites and small mission test-beds, including ISS
  - *Includes evaluations of operations, control systems, displays, etc*
  - *Leverage ongoing field studies liking to existing SMD-HEOMD joint efforts*
- Identify and advocate investments in relevant robotics technologies
  - *sensing, mobility, manipulation, human systems integration, autonomy*
- Enable discussion on international collaboration and public/private partnerships